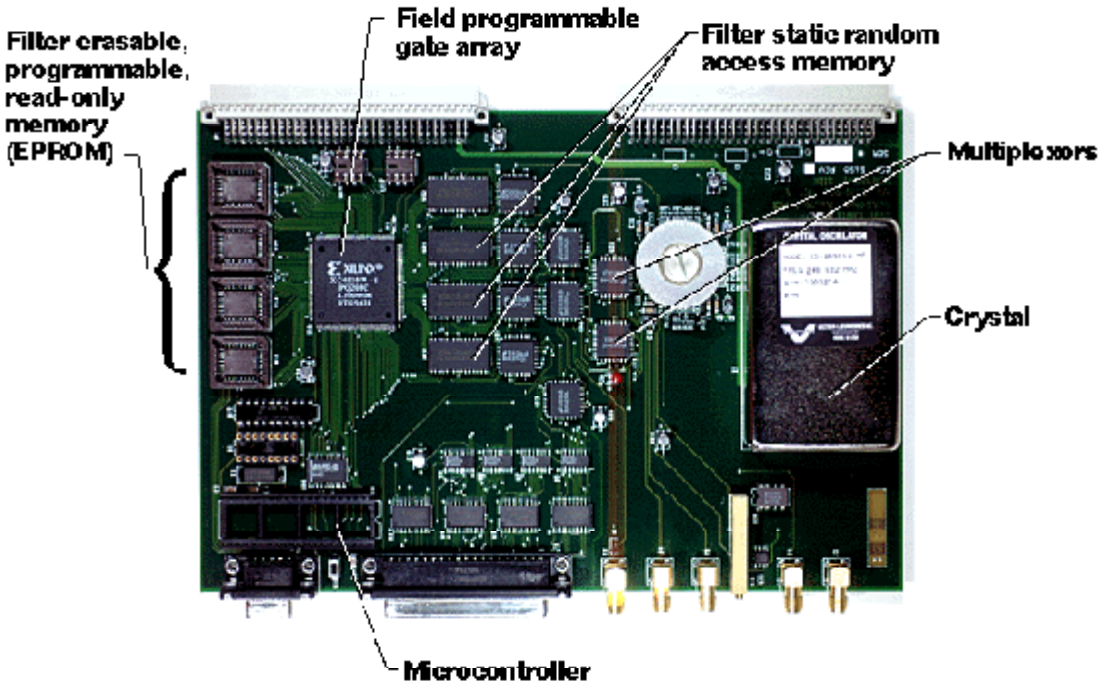
Low-Complexity, Digital Encoder/Modulator Developed for High-Data-Rate Satellite B-ISDN Applications

The Space Electronics Division at the NASA Lewis Research Center is developing advanced electronic technologies for the space communications and remote sensing systems of tomorrow. As part of the continuing effort to advance the state-of-the-art in satellite communications and remote sensing systems, Lewis developed a low-cost, modular, programmable, and reconfigurable all-digital encoder-modulator (DEM) for medium- to high-data-rate radiofrequency communication links. The DEM is particularly well suited to high-data-rate downlinks to ground terminals or direct data downlinks from near-Earth science platforms. It can support data rates up to 250 megabits per second (Mbps) and several modulation schemes, including the traditional binary phase-shift keying (BPSK) and quadrature phase-shift keying (QPSK) modes, as well as higher order schemes such as 8 phase-shift keying (8PSK) and 16 quadrature amplitude modulation (16QAM). The DEM architecture also can precompensate for channel disturbances and alleviate amplitude degradations caused by nonlinear transponder characteristics.

In addition to higher order modulation schemes, a combination of modulation and forward-error correction coding is used to improve the efficiency of conveying information through the power- and bandwidth-limited channels that are characteristic of spaceborne systems. In these systems, onboard power and frequency allocation is at a premium. The DEM's baseline bandwidth efficient modulation technique provides a factor of 2 improvement in bandwidth efficiency over the Consultative Committee for Space Data Systems (CCSDS) standard and nearly 6 orders of magnitude improvement in quality of service. This feature enables bandwidth-efficient, high- data-rate communications without requiring excessively sized, onboard radiofrequency power amplifiers, thus reducing overall spacecraft mass and power.

The modular, programmable, and reconfigurable architecture of the DEM provides a unique level of mission design flexibility, allowing the same package to be used on many kinds of spacecraft with a wide variety of communications needs. Often complex programmable designs become very inefficient in terms of power, size, and mass at other than the highest data rates. The programmable feature allows mission designers to use the same package to provide various levels of communications services depending on the rates required. The unique degree of flexibility afforded by this package will lead to a significant reduction in spacecraft life-cycle costs by reducing nonrecurring development costs for modules that satisfy the needs of only one spacecraft design.



Digital encoder/demodulator.

The prototype hardware that is shown in the figure consumes approximately 18 W, is assembled on a 6U by 160-mm VME card, and weighs approximately 40 oz. The use of low-complexity digital signal processing techniques has nearly halved the size and mass of comparable state-of-the-practice designs. Future work will focus on further reducing the size, power, and mass of the unit. An approach under consideration is the design and development of a custom, multichip module to perform the majority of the DEM functions.